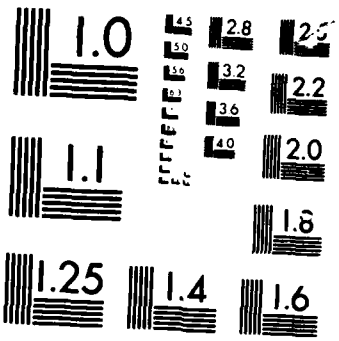
AD-A169 175 INAUGURAL CONFERENCE OF THE BERKELEY RESEARCH GROUP IN NONLINEAR SYSTEMS AND DYNAMICS(U) CALIFORNIA UNIV BERKELEY S S SASTRY MAY 86 ARO-22553.1-MA-CF 1/1

UNCLASSIFIED DAAG29-85-K-0166 F/G 6/4 NL



MICROCOPY CHART

MASTER COPY - FOR REPRODUCTION PURPOSES

(2)

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARO 22553.1-MA-CF	2. GOVT ACCESSION NO. N/A	3. RECIPIENT'S CATALOG NUMBER N/A
4. TITLE (and Subtitle) Inaugural Conference of the Berkeley Research Group in Nonlinear Systems and Dynamics		5. TYPE OF REPORT & PERIOD COVERED 7 Jan 85 - 6 Jan 86 Final Report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) S. S. Sastry		8. CONTRACT OR GRANT NUMBER(s) DAAG29-85-M-0166
9. PERFORMING ORGANIZATION NAME AND ADDRESS University of California, Berkeley Berkeley, CA 94720		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Research Office Post Office Box 12211 Research Triangle Park, NC 27709		12. REPORT DATE May 1986 13. NUMBER OF PAGES 11
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

DTIC ELECTE JUN 26 1986 S D

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

NA

18. SUPPLEMENTARY NOTES

The view, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Robotics
Molluscan Shells
Turbulence
Nonlinear Filtering
Solid State Systems
Conferences

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The conference was held as scheduled. Included in the presentations were the following papers:

"Nonlinear Problems in Robotics"
"The Patterns on Molluscan Shells"
"Turbulence and Low Dimensional Chaos"
"A Geometric and Asymptotic Approach"
"Experiments on Nonlinear Dynamics in Solid State Systems"
"Spectral Universality in Macromolecular Sensitivity"

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

AD-A169 175

DTIC FILE COPY

ARO 22553.1-MA-CF

20. ABSTRACT CONTINUED

"Global Dyanmical Properties"

ARO 22553.1-MA-CF

ABSTRACTS
FIRST INAUGURAL CONFERENCE
NONLINEAR SYSTEMS & DYNAMICS

"Nonlinear Problems in Robotics"

Roger W. Brockett
(Harvard University)

In this talk we describe two types of problems in robotic manipulations. The first is the problem of inverting the map from joint angles to the position and orientation of the end effector. The second is a detailed analysis of the solid-solid interaction required to grasp and manipulate rigid bodies such as woeld be appropriate in the programming of robotic hands.

"Global Bifurcations in Nonlinear Oscillators, or Birkhoff's Bagel, Smale's Horseshoe and Josphson's Function."

Phillip Holmes (Cornell University)

We describe some of the dynamical behavior resulting from the presence of rotary, transverse homoclinic orbits in diffeomorphisms of the annulus. We show that their presence implies that an interval I of rotation numbers exists (a result due to Aronson et al.) and that for each irrational number $\alpha \in I$ there exist uncountably many invariant Cantor sets having rotation number α. We show that the Josephson equation

$$\ddot{x} + \delta\dot{x} + \sin x = 0 + \beta\cos\omega t$$

has such a homoclinic orbit for suitable choices of the parameters $(\nu,\beta,\delta,\omega)$, and hence that its attracting set contains complicated "irrational" orbits.

86 6 25 177

THE PATTERNS ON MOLLUSCAN SHELLS (WITH GEORGE OSTER)

by

Bard Ermentrout

University of Pittsburgh

ABSTRACT

A simple model combining neural and secretory cells is proposed as an explanation of the patterns on molluscan shells. The model comprises two nonlinear neural networks coupled with a discrete-time secretory cell. Many of the patterns can be reproduced with this model. Numerical simulations and linear stability analysis are used to study the various patterns produced by the model. Extensions of the model and complexities of the shell patterns are discussed.

Accesion For
NTIS CRA&I ☒
DTIC TAB ☐
Unannounced ☐
Justification
By
Distribution /
Availability Codes
Dist | Avail and / or Special
A-1

QUALITY INSPECTED 3

"Turbulence and Low Dimensional Chaos
in Hydrodynamical Systems"
Michael Gorman (Houston)

The role of the ideas of nonlinear dynamics in describing the transition to turbulence in hydrodynamical systems will be critically reviewed. Experiments from three classes of systems will be discussed. As an example of chaotic but not turbulence flows, the flow in a loop of fluid heated on the bottom and cooled on the top will be shown to be described by the nonlinear dynamics of the Lorenz model. As an example of chaotic and turbulent fluid flows in closed systems the transition to turbulence in the flow between two concentric cylinders (with the outer cylinder at rest) will be shown to be described by low dimensional chaos. As an example of chaotic and turbulent fluid flows in open systems the transition to turbulence in the flow behind a cylinder will be shown to be extremeley suggestive of low dimensional chaos .

"A Geometric and Asymptotic Approach
to Nonlinear Filtering"
Arthur J. Krener (UC Davis)

We associate to dynamic observations a set of functions which transforms like Christoffel symbols. A necessary condition for linearizability of the dynamic observations is that these symbols define a flat and torsion free connection on the output space.

We use this technique to partially linearize a nonlinear filtering problem. If the observation and some of the driving noises are small in a way that is compatible with the nonlinearities, then the nonlinear filtering can be solved using a Girsanov transformation and an asymptotic expansion. The resulting filter resembles an Extended Kalman Filter but is asymptotically optimal.

Experiments on Nonlinear Dynamics in Solid State Systems

A brief review was given of experiments on three systems displaying nonlinear dynamics, with the common feature that they are roughly modelled by coupled oscillators or modes. (1) Helical electron-hole plasma density waves in a germanium crystal in parallel electric and magnetic fields exhibit a period doubling cascade to chaos and also a quasiperiodic route. The measured fractal dimension of the strange attractor, dim $\approx$ 2.6, shows that this spatio-temporal system may be modelled by only a few degrees of freedom, for example, three nonlinearly coupled waves. (2) Standing modes of spin wave packets in ferrite spheres show period doubling, chaos, and periodic windows; some modes show only small dissipation. (3) Coupled p-n junctions in silicon, resonantly driven into charge injection, provide a realizable system of coupled, very nonlinear oscillators. They show period doubling, period adding, quasiperiodicity (up to four incommensurate frequencies), entrainment horns, breakup of tori, and chaos. Behavior can be roughly understood from coupled maps of the plane.

Alison Jeffries.
UCB

ABSTRACT

"Fish Gotta Swim: Coupled Oscillators and Locomotion"

by N. Kopell
Northeastern

Many stereotypic rhythmic motions in vertebrates, such as fish locomotion, are controlled by neurological programs ("central pattern generators") in the spinal cord that are thought to involve coupled oscillators. The neural patterns associated with fish swimming are shown to be consequences of very few robust (and physiologically reasonable) hypotheses on the oscillators and the coupling. The key hypothesis is that the coupling is not diffusive. The mathematics involves the analysis of a long chain of weakly coupled limit cycle oscillators, whose behavior turns out to be approximated by a continuum limit.

Abstract

The Effect of Phase Space Islands on Stochasticity and Diffusion, and Diffusion in More than 2 Degrees of Freedom*

by

Allan Lichtenberg, UCB

The phase space of a conditionally-periodic 2-degree-of-freedom Hamiltonian, or a corresponding area preserving mapping, is explored. It is shown, numerically, and justified by simple analytic calculations, that resonances between the two degrees of freedom lead to modification of the phase space structure (islands). The islands interact to give regions of the phase plane of the mapping or surface of section in which the motion is stochastic (area filling). A resonance renormalization theory is developed to calculate qualitatively the transitions between regular (KAM) motion and stochastic motion, and to aid the understanding of the process by which the transitions are created. A procedure is developed for calculating the rate of diffusion in action space for those portions of the phase space in which phase correlations exist between mapping iterations, and in which invariant structures (islands) may also be present.

In systems with more than 2-degrees of freedom, diffusion occurs along resonances as well as across resonances. The phenomenon has been explored for the example of Electron Cyclotron Resonance Heating (ECRH), in a magnetic mirror, with two driving frequencies. With single frequency ECRH there is heating due to stochastic motion perpendicular to the magnetic field, but the heating is limited by a KAM barrier. The addition of a 2nd frequency allows both diffusion in parallel as well as perpendicular energy and also slow diffusion to arbitrary perpendicular energies. The rates of diffusion are estimated analytically and compared with numerical calculations.

*The work is in collaboration with M. A. Lieberman. It is supported in part by ONR Contract N0000014-84-K0367 and NSF Grant ECS-8104561.

Inaugural Conference
Research Group in Nonlinear Systems and Dynamics
University of California, Berkeley
January 7-8, 1985

SPECTRAL UNIVERSALITY IN MACROMOLECULAR SENSITIVITY

Arnold J. Mandell, M.D.
Department of Psychiatry
University of California, San Diego

Fourier transformation of Raman relaxation spectra of proteins in solution and time series of the biochemical behavior of brain enzyme and receptor preparations indicates that responsivity to new information is associated with a continuous frequency (power) spectrum that scales as $\omega^{0.62 \pm 0.05}$ across time scales ranging from 10^{-6} to 10^{3} seconds. Desensitization of protein systems is associated with the emergence of a spectral near-Δ function in the higher frequencies and a gap in the middle frequencies. The exquisite sensitivity to autonomous denaturation of proteins in solution at 37° due to their high internal energy requires that mode-locking be avoided to maintain functional capacity. This suggests an analogy with the KAM problem: preservation of stable quasiperiodicity in T^n necessitating a maximally irrational winding number ($|\overline{w} - p/q| > K/q^{2+\sigma}$) that is the inverse of the golden mean, 0.618..., with a non-terminating periodic continued fraction representation $\langle 1,1,1\ldots\rangle$. The limit of geometric proportionality implicit in the hydrophobic aggregation of protein self-organization leads to the same value: $a/b = a + b$; $b/a = x$; $x^2 = 1 + x \rightarrow 1.618, 0.618$.

The universal "1/f noise" of biological fluctuations (resting membrane ion conductances, depolarization spectra in stimulated axons, cellular hormone release patterns, cardiac interbeat intervals, electrocorticograms, swaying on one foot, voice prints, aesthetics in music and art, etc.) is interpreted as reflecting the self-similar spectrum of the maximally irrational, geometrically proportional winding number of metastable proteins across biological time scales. These findings resemble the universal spectral behavior of two-parameter families of maps of the plane near the strong coupling fixed point if the irrational winding number can be expressed as a periodic continued fraction.

ABSTRACT

"Global Dynamica Properties"

By Basil Nicolaenko-CNLS

ABSTRACT

We explicit some global dynamical properties for a class of pattern formation equations on unstable flame fronts and thin hydrodynamic films. Such equations, including the Kuramoto-Sivashinsky model, are characterized by the coexistence of coherent spatial structures with temporal chaos. We investigate their nonlinear stability and we give rigorous estimates for the fractal dimension of the corresponding strange attractors, as a function of a typical pattern cell size. We outline some recent results (obtained jointly with C. Foias, G. Sell and R. Temam) on the existence of a finite-dimensional global inertial manifold, which determines the asymptotic dynamics for all initial data.

An Equal Opportunity Employer/Operated by University of California

ABSTRACT

"Nonlinear Methods in Minimal Surface Theory"

by A. Tromba - UCSC

It can be shown that there is a notion of non-degeneracy for minimal surfaces which generalizes the classical notion of "non-degenerate" Hessian. In $\mathbb{R}^3$ there are minimal surfaces which are formally degenerate in the Hessian sense but non-degenerate in the broader sense. In $\mathbb{R}^n$, $n \geq 4$ these two notions coincide. Moreover for almost all boundary contours the minimal surfaces in $\mathbb{R}^3$ bounded by these contours are non-degenerate in this broader sense but not in the traditional sense.

"Dynamics of Phase-Locked Loops:
Open Problems"
Douglas N. Green (UCLA)

This talk presents the model and known results on the behavior of phase-locked loops (PLLs). For analog PLLs, there are some results related to the 2nd order ODE work on Josephson Junctions. However, these conclusions are not useful for the parameter ranges of PLLs in determing the key property of the PLL behavior--determing whether the PLL acquires (converence to the stable equilibrium). Also, no useful results are available for PLL acquisition in the presence of small data and noise. Models of AGC-aided PLLs, digital PLLs, and switched-capacitor PLLs are presented. These last two are described by 2nd order difference equations. Very little results are available on their behavior, i.e., on PLL acquisition. In summary, much work has yet to be done on the important practical problem of PLL dynamic behavior and acquistion.

"Some Attractive Non-Linearities in Fluid Mechanics"

By Joseph Humphrey
UCB

Visualization observations are reported for the time evolving vortex structure at the interface of a counter-current channel flow. The results are primarily qualitative in nature, but show clearly the evolution of a two-dimensional saddle-point flow into a complex, three-dimensional, periodic vortex-pairing process. Generation, pairing and collapse of the flow structure at the free interface is attributed to tilting and stretching of transverse vorticity by the main flow in the longitudinal direction. It is suggested that the present flow configuration may prove of use for investigating mixing in chemically reacting flows due to entraining vortex motions.

END

DTIC

7-86